Attorney Docket 0553-0372

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Application of)
)
Satoshi MURAKAMI et al.)
)
Serial No.: 10/621,989)
)
Filed: July 17, 2003)
)
For: Method Of Fabricating Light Emitting Device)
)
Art Unit: 2879)
)
Examiner: Mariceli Santiago)

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on

November 16 2005
(Date of Deposit)

Shannon Wallace
Name of applicant, assignee, or Registered Rep.

Shannon Wallace 11/16/05
Signature Date

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL OF VERIFIED ENGLISH TRANSLATION OF PRIORITY DOCUMENT

Sir:

In response to the Final Rejection of October 20, 2005 and in furtherance of Amendment A filed on September 27, 2005, (in response to the Office Action dated June 27, 2005), Applicants are submitting herewith a verified English translation of the priority document, Japanese patent application 2002-217248 filed on July 25, 2002.

The present application was filed on July 13, 2003 and claims the benefit under 35 USC §119 of Japanese patent application 2002-217248 filed on July 25, 2002.

The certified copy of the foreign priority application 2002-217248 was filed in the present application on July 17, 2003.

Hence, the present application can claim the benefit of the July 25, 2002 filing date of the Japanese priority application.

If any fee is due for this submission, please charge our deposit account 50/1039.

Favorable consideration is earnestly solicited.

Respectfully submitted,

Date: November 16, 2005

Mark J. Murphy
Registration No. 34,225

COOK, ALEX, McFARRON, MANZO,
CUMMINGS & MEHLER, LTD.
200 West Adams Street, Suite 2850
Chicago, Illinois 60606
(312) 236-8500

Customer no. 000026568

Docket No.: 0553-0372

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:	)
Satoshi MURAKAMI et al.	)
Application No.: 10/621,989	) Examiner:
Filed: July 17, 2005	) Mariceli Santiago
For: METHOD OF FABRICATING	) Group Art Unit:
LIGHT EMITTING DEVICE	) 2879

VERIFICATION OF TRANSLATION

Commissioner for Patents
P.O.Box 1450
Alexandria, VA 22313-1450

Sir:

I, Yuri Taniguchi, C/O Semiconductor Energy Laboratory Co., Ltd. 398, Hase, Atsugi-shi, Kanagawa-ken 243-0036 Japan, a translator, herewith declare:

that I am well acquainted with both the Japanese and English Languages;

that I am the translator of the attached translation of the Japanese Patent Application No. 2002-217248 filed on July 25, 2002; and

that to the best of my knowledge and belief the following is a true and correct translation of the Japanese Patent Application No. 2002-217248 filed on July 25, 2002.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: this 1st day of November, 2005

Yuri Taniguchi

Name: Yuri Taniguchi

[Name of Document] Patent Application

[Reference Number] P006514

[Filing Date] July 25, 2002

[Attention] Commissioner, Patent Office, Kouzo Oikawa

[International Patent Classification] H01L 21/00

[Inventor]

[Address] 398, Hase, Atsugi-shi, Kanagawa-ken, c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Satoshi Murakami

[Inventor]

[Address] 398, Hase, Atsugi-shi, Kanagawa-ken, c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Ritsuko Nagao

[Inventor]

[Address] 398, Hase, Atsugi-shi, Kanagawa-ken, c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Masayuki Sakakura

[Inventor]

[Address] 398, Hase, Atsugi-shi, Kanagawa-ken, c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Misako Nakazawa

[Inventor]

[Address] 398, Hase, Atsugi-shi, Kanagawa-ken, c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Noriko Miyagi

[Inventor]

[Address] 398, Hase, Atsugi-shi, Kanagawa-ken, c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Hisao Ikeda

[Inventor]

[Address] 398, Hase, Atsugi-shi, Kanagawa-ken, c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Kaoru Tsuchiya

[Inventor]

[Address] 398, Hase, Atsugi-shi, Kanagawa-ken, c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Ayumi Ishigaki

[Inventor]

[Address] 398, Hase, Atsugi-shi, Kanagawa-ken, c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Masahiro Takahashi

[Inventor]

[Address] 398, Hase, Atsugi-shi, Kanagawa-ken, c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Noriyuki Matsuda

[Inventor]

[Address] 398, Hase, Atsugi-shi, Kanagawa-ken, c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Hiroki Ohara

[Applicant]

[Identification Number] 000153878

[Name] Semiconductor Energy Laboratory Co., Ltd.

[Representative] Shunpei Yamazaki

[Indication of Handling]

[Number of Payment Note] 002543

[Payment Amount] 21000

[List of Attachment]

[Attachment] Specification 1

[Attachment] Drawing 1

[Attachment] Abstract 1

[Necessity of Proof] Necessary

[Document Name] Specification

[Title of the Invention]

SEMICONDUCTOR DEVICE AND MANUFACTURING METHOD THEREOF

[Scope of Claim]

[Claim 1]

A method of fabricating a light emitting device having a light emitting element having an anode, a layer containing an organic compound, which is in contact with said anode, and a cathode which is in contact with said layer containing an organic compound, characterized by comprising the steps of:

forming said anode;

forming an insulating material for covering end portions of said anode;

washing a surface of said anode with a porous sponge;

performing vacuum heating immediately before said layer containing an organic compound is formed;

forming said layer containing an organic compound; and

forming said cathode.

[Claim 2]

A method of fabricating a light emitting device having a light emitting element having an anode, a layer containing an organic compound, which is in contact with said anode, and a cathode which is in contact with said layer containing an organic compound, characterized by comprising the steps of:

forming said anode;

washing a surface of said anode with a porous sponge;

forming an insulating material for covering end portions of said anode;

performing vacuum heating immediately before said layer containing an organic compound is formed;

forming said layer containing an organic compound; and

forming said cathode.

[Claim 3]

A method of fabricating a light emitting device having a light emitting element having an anode, a layer containing an organic compound, which is in contact with said anode, and a cathode which is in contact with said layer containing an organic compound, characterized by comprising the steps of:

forming said anode;

washing a surface of said anode with a porous sponge;

forming an insulating material for covering end portions of said anode;

washing a surface of said anode with a porous sponge;

performing vacuum heating immediately before said layer containing an organic compound is formed;

forming said layer containing an organic compound; and

forming a cathode.

[Claim 4]

A method of fabricating a light emitting device having a light emitting element having an anode, a layer containing an organic compound which is in contact with said anode, and a cathode which is in contact with said layer containing an organic compound, characterized by comprising the steps of:

forming an organic insulating film for covering a TFT;

forming a silicon nitride film or a silicon oxide film over said organic insulating film by a sputtering method;

forming said anode electrically connected to said TFT over said nitride silicon film;

forming an insulating material for covering end portions of said anode;

washing a surface of said anode with a porous sponge;

performing vacuum heating immediately before said layer containing an organic compound is formed;

forming said layer containing an organic compound; and

forming a cathode.

[Claim 5]

A method of fabricating a light emitting device according to any one of claims

1 to 4, characterized in that a temperature of said vacuum heating is from 100°C to 250°C.

[Claim 6]

A method of fabricating a light emitting device according to any one of claims 1 to 5, characterized in that the step of performing said vacuum heating, the step of forming said layer containing an organic compound and the step of forming said cathode are in order carried out in series without being exposed to an atmospheric air.

[Claim 7]

A method of fabricating a light emitting device having a light emitting element having an anode, a layer containing an organic compound which is in contact with said anode and a cathode which is in contact with said layer containing an organic compound, characterized by comprising the steps of:

forming said anode;

forming an insulating material for covering end portions of said anode;

washing a surface of said anode with a porous sponge;

forming a layer containing a first organic compound which is in contact with said anode by a coating method;

performing vacuum heating immediately before a layer containing a second organic compound is formed;

forming said layer containing a second organic compound by a vapor deposition method; and

forming a cathode.

[Claim 8]

A method of fabricating the light emitting device according to claim 7, characterized in that said layer containing a first organic compound is made of a high-molecular weight material, and said layer containing a second organic compound is made of a low-molecular weight material.

[Claim 9]

A method of fabricating the light emitting device according to claim 7 or 8, characterized in that a temperature of said vacuum heating is 100°C to 200°C.

[Claim 10]

A method of fabricating the light emitting device according to any one of claims 1 to 9, characterized in that said vacuum heating has a degree of vacuum of 1×10^{-3}Pa to 1×10^{-6}Pa.

[Claim 11]

A method of fabricating the light emitting device according to any one of claims 1 to 10, characterized in that said step of forming said cathode is performed by a resistance heating method or a sputtering method.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention pertains]

The present invention relates to a semiconductor device including a circuit consisting of thin film transistors (hereinafter referred to as TFT) and a manufacturing method thereof. For example, it relates to a light emitting device using a light emitting element emitting fluorescence or phosphorescence by applying an electric field to an element provided a film including an organic compound (hereinafter referred to as "organic compound layer") between a pair of electrodes, and to a manufacturing method thereof. Note that a light emitting device in this specification includes an image display device, a luminescent device and a light source (including illuminating devices). Further, a light emitting device includes all of a module of a light emitting device attached with a connector, for example, a FPC (Flexible printed circuit) or TAB (Tape Automated Bonding) tape or TCP (Tape Carrier Package), a module provided with a printed wiring board at a front end of the TAB tape or the TCP or a module in which IC (integrated circuit) is directly mounted with a light emitting element by COG (Chip On Glass) system.

[0002]

Note that a semiconductor device in this specification indicates general apparatuses that are capable of functioning by utilizing semiconductor characteristics and all of an electro-optical device, a light emitting device, a semiconductor circuit and

an electronic equipment are a semiconductor device.

[0003]

[Prior Art]

There is expected application of a light emitting element using an organic compound having a characteristic of thin shape, light weight, high response and direct current low voltage drive or the like as a light emitting body to a flat panel display of next generation. Particularly, a display device arranged with light emitting elements in a matrix shape seems to be superior to a conventional liquid crystal display device in view of wide viewing angle and excellence in optical recognizing performance.

[0004]

According to the light emitting mechanism of a light emitting element, it is said that an electron injected from a cathode and a hole injected from an anode are recombined at a center of light emission in the organic compound layer to form molecular exciton by interposing an organic compound layer between a pair of electrodes and applying voltage, and when the molecular exciton returns to the ground state, energy is discharged to emit light. There are known singlet excitation and triplet excitation in excited state and it seems that light can be emitted by experiencing either of the excited states.

[0005]

It is possible to use driving methods such as passive matrix drive (simple matrix type) and active matrix drive (active matrix type) for a light emitting device formed by arranging such light emitting elements in a matrix shape. However, when a pixel density is increased, the active matrix type provided with switches for each pixel (or 1 dot) is advantageous since it can be driven at low voltage.

[0006]

Further, although a low molecular system material and high molecular system (polymer system) material have been respectively researched for the organic compound for constituting the organic compound layer (strictly speaking, light emitting layer) regarded to be the core of a light emitting element, more attention is paid to the high molecular system material facilitated to handle and having high heat resistance than the

low molecular system material.

[0007]

Further, although there are known methods such as vapor deposition method, spin coating method and ink jet method for a film formation method of the organic compounds, as a method for realizing full color by using the high molecular system material, the spin coating method and the ink jet method are particularly well known.

[0008]

The light emitting elements having the organic compound has a defect that is easy to be deteriorated by various factors, therefore reliability (long lifetime) is a maximum object.

[0009]

[Problems to be Solved by the Invention]

A light emitting element having an organic compound is easily deteriorated mainly due to water and oxygen, and as a failure state caused by these causing factors, a state in which the lowering of brightness has partially occurred or a non-light emitting region has been generated is seen.

[0010]

Moreover, a state in which the expansion of the non-light emitting region progresses is also seen as the changes occurring only along with the passing time, or as the changes occurring when the time passes while the light emitting element is driven. Particularly, in the case where a non-light emitting region is generated at the stage immediately after a light emitting element having an organic compound has been fabricated, the expansion of the non-light emitting region often progresses along with the time passing, and it may be also seen that it progresses further until finally the entire region becomes the non-light emitting region.

[0011]

Moreover, the non-light emitting region is easier generated from the circumferential portion of the light emitting region, and since the expansion of the non-light emitting region progresses along with the time passing as if the light emitting region shrinks, this failure mode is referred to as a shrink. It should be noted that in

Fig.11(A), a light emitting state immediately after the light emitting element has been fabricated is shown, and that in Fig.11(B), how the shrink was generated when the time passed immediately after the light emitting element had been fabricated is shown. Fig.11(B) shows an example in which it is uniformly generated from the circumferential portion of the light emitting region, however, it may occur that the circumference of the light emitting region becomes convex and concave shapes as the shrink ununiformly progresses.

[0012]

Because the light emitting area reduces, in such a case where the area of the light emitting region is as small as that of an active matrix type light emitting device, particularly the failures means that a certain light emitting element becomes a non-light emitting element at an early timing. And further, in the case where the area of the light emitting region is small, if the light emitting area is reduced, the ratio occupied by the non-light emitting region is enlarged. Therefore, in the case where a display device is fabricated by using a light emitting element, it is difficult to obtain a highly-defined (whose pixel pitch is small) and highly reliable display.

[0013]

Moreover, a non-light emitting region just like the sunspot may be generated immediately after a light emitting element having an organic compound has been fabricated, and this failure mode is referred to as a dark spot. Moreover, this dark spot may be also expanded along with the time passing. It should be noted that Fig.12(A) is a figure showing that a dark spot exists at the third one from the top of the left row, at the first one and sixth one from the top of the right row immediately after the light emitting element has been fabricated, and how the expansion of the dark spot is generated when the time passed from the time immediately after the light emitting element has been fabricated is shown in Fig.12(B). In Fig.12(B), a shrink is also generated at the same time with the expansion of the dark spot.

[0014]

An object of the present invention is to reduce or eliminate the occurrence of the above-described various failure modes in a light emitting element having an organic

compound.

[0015]

[Means for Solving the Problem]

The present inventors have found that a cause of a non-light emitting region generated immediately after the light emitting element having an organic compound has been fabricated is mainly attributed to the crack of an anode, and the shape of barrier (which is also referred to as bank or embankment) disposed between the respective anodes by a plurality of experiments.

[0016]

Then, it is preferable that in the present invention, a surface which is in contact with the lower surface of an anode is made flat in order to prevent a crack of an anode, for example, in the case where an anode is formed on an inter layer dielectric film such as an organic resin film, the crack of the anode can be prevented by providing a silicon nitride film between an organic resin film and an anode using a RF sputtering method and making the coverage excellent. It should be noted that a HMDS treatment might be performed in order to enhance the adherence between an organic resin film and a silicon nitride film. Moreover, if a constitution in which only an inorganic insulating film (silicon oxide film provided by a PCVD method) being in contact with the lower surface of an anode is provided as an inter layer dielectric film is made, a non-light emitting region generated immediately after the light emitting element has been fabricated can be nullified.

[0017]

Moreover, in the present invention, a non-light emitting region generated immediately after the light emitting element has been fabricated can be eliminated by making the shape of a barrier (which is also referred to as a bank or embankment) disposed between the respective anodes into a shape having a less roughness of the surface and a tapered shape that is gently sloped, and desirably, the shape having a curved surface having a radius of curvature at the upper end or lower end portions to make a coverage of a cathode excellent (its example is shown in Fig.2(B) or Fig.3).

[0018]

Moreover, the present inventors have found that a dark spot generated immediately after the light emitting element having an organic compound has been fabricated can be mainly attributed to minute grains dotted on the surface of an anode.

[0019]

In Fig.13, a sectional photograph of TEM is shown. In Fig.13, it can be observed that minute grains having a size of less or equal to 0.1μm in a spherical shape exist on the ITO. It should be noted that Fig.13 is a sectional diagram showing the state after a light emitting element has been emitted, that is, after it has been energized. Moreover, when an EDX measurement (Fig.14, Fig.15 and Fig.16) was carried out at three points on the section of Fig.13, it was found that the component of the minute grain was approximately the same with that of ITO. These minute grains seem to be a dust in the film formation of the ITO by a sputtering method, a dust in the wet etching step of a barrier, or a dust in the patterning step of the ITO film. Moreover, there may be also a case where the current is locally concentrated by the minute grains and then, the bright spot (location whose brightness is higher than those of the surroundings) is generated.

[0020]

Then, in the present invention, in order to remove the minute grains dotted on the surface of an anode, a surfactant (weak alkali) is contained in a porous sponge (representatively, made of PVA (polyvinyl alcohol) or nylon) and the surface of the anode is rubbed and washed. Furthermore, in the case where the washing has not been carried out, there have been problems such that the minute grain causes a local short circuit between the anode and cathode and the whole of one pixel becomes non-light emitting (point defect), or an abnormality in an electrical characteristics of the fabricated light emitting element is observed. It should be noted that as for the electrical characteristics of a light emitting element fabricated without washing, the brightness with respect to the voltage is hardly changed, whereas the abnormality that the light emitting efficiency is extremely lowered in the drive at a low voltage (3V to 5V) is observed. In order to solve these problems too, it is effective that a surfactant is contained in a porous sponge and the surface of the anode is rubbed and washed. In

Fig.5, the electrical characteristics of a light emitting element to which washing was not carried out, and the electrical characteristics of a light emitting element to which washing (TMAH (tetramethyl ammonium hydroxide), CD200CR) was carried out, are shown. Moreover, the washing using the sponge may be carried out a plurality of times prior to the formation of the barrier or after the formation of the barrier, or prior to and after the formation of the barrier. Moreover, as a washing mechanism, a washing apparatus having a rolling brush (made by PVA) which comes in contact with the surface of the substrate while it rotates around the axis line which is in parallel to the surface of the substrate may be used, or a washing apparatus having a disc brush (made by PVA) which comes in contact with the surface of the substrate while it rotates around the axis line which is vertical to the surface of the substrate may be also used.

[0021]

Moreover, the present inventors have found that a shrink in which the non-light emitting region is expanded is mainly attributed to the phenomenon that a minute amount of water including absorbed water reaches to a layer containing an organic compound.

[0022]

Then, in the present invention, it is desirable that the water existing within the active matrix substrate (including absorbed water) is removed immediately before the layer containing an organic compound is formed on an active matrix substrate having a TFT, so, by performing the vacuum heating at 100°C to 250°C prior to the formation of the layer containing an organic compound, the prevention of occurrence or reduction of a shrink can be done. Particularly, in the case where an organic resin film is used as a material of an inter layer dielectric film and a barrier, since water is easily absorbed depending upon an organic resin material, and further, since there may be a fear that degassing may occur, it is effective to perform the vacuum heating at 100°C to 250°C prior to the formation of the layer containing an organic compound.

[0023]

Furthermore, in the present invention, in order to prevent water from invading into the layer containing an organic compound, it is preferable to conduct the step from

forming the layer containing an organic compound up to the step of sealing it without being exposed to the atmospheric air.

[0024]

Moreover, in the case where the barrier is formed with an organic resin film, the prevention of occurrence or reduction of a shrink can be carried out by covering the barrier with a silicon nitride film by a RF sputtering method. It should be noted that in order to enhance the adhesiveness between the barrier composed of an organic resin film and the silicon nitride film, a HMDS treatment may be carried out.

[0025]

Furthermore, the invasion of water into the layer containing an organic compound may be prevented by thickening the film thickness of cathode to be greater than or equal to 400 nm.

[0026]

The constitution of the present invention disclosed in the present specification is,

a method of fabricating a light emitting device having a light emitting element having an anode, a layer containing an organic compound which is in contact with the anode, and a cathode which is in contact with the layer containing an organic compound, characterized by comprising,

forming the anode,

forming an insulating material for covering the end portions of the foregoing anode,

washing a surface of the foregoing anode with a porous sponge,

performing vacuum heating immediately before the layer containing an organic compound is formed,

forming the layer containing an organic compound, and

forming the cathode.

[0027]

Moreover, it may be washed before the formation of the insulating material which is to be a barrier, and another constitution of the invention is,

a method of fabricating a light emitting device having a light emitting element having an anode, a layer containing an organic compound which is in contact with the anode, and a cathode which is in contact with the layer containing an organic compound, characterized by comprising the steps of

forming the anode,

washing a surface of the foregoing anode with a porous sponge,

forming an insulating material for covering the end portions of the foregoing anode,

performing vacuum heating immediately before the layer containing an organic compound is formed,

forming the layer containing an organic compound, and

forming the cathode.

[0028]

Moreover, washing may be conducted before and after an insulating material to be a barrier is formed, and another constitution of the invention is,

a method of fabricating a light emitting device having a light emitting element having an anode, a layer containing an organic compound which is in contact with the anode, and a cathode which is in contact with the layer containing an organic compound, characterized by comprising the steps of

forming the anode;

washing a surface of said anode with a porous sponge;

forming an insulating material for covering end portions of said anode;

washing a surface of said anode with a porous sponge;

performing vacuum heating immediately before a layer containing an organic compound is formed;

forming the layer containing an organic compound; and

forming the cathode.

[0029]

Moreover, it is preferable that an insulating film being in contact with the lower surface of an anode is made with an inorganic insulating film, and another constitution

of the invention is,

a method of fabricating a light emitting device having a light emitting element having an anode, a layer containing an organic compound which is in contact with the anode, and a cathode which is in contact with the layer containing an organic compound, characterized by comprising the steps of

forming an organic insulating film for covering a TFT,

forming a silicon nitride film or a silicon oxide film on an organic insulating film by a sputtering method,

forming an anode which is electrically connected to the foregoing TFT on the silicon nitride film,

forming an insulating material for covering the end portions of the foregoing anode,

washing a surface of the foregoing anode with a porous sponge,

performing vacuum heating immediately before the layer containing an organic compound is formed,

forming the layer containing an organic compound, and

forming the cathode.

[0030]

In the constitutions described above, it is characterized in that the temperature of the foregoing vacuum heating is in the range from 100°C to 250°C, and absorbed water of the substrate is removed and the occurrence of a shrink is suppressed.

[0031]

In the constitutions described above, it is preferable that the step of performing the foregoing vacuum heating, the step of forming the foregoing layer containing an organic compound, and the step of forming the foregoing cathode are in order and continuously performed without being exposed to the atmospheric air, and it is more preferable that by continuously performing the steps up to the step of sealing without being exposed to the atmospheric air, the invasion of water and oxygen is suppressed and the reliability is enhanced.

[0032]

Moreover, after a layer containing a first organic compound composed of a high-molecular weight material, which is in contact with the anode washed with a sponge, was formed into a film by a coating method, the vacuum heating at 100°C to 200°C is performed immediately before a layer containing a second organic compound composed of a low-molecular weight material is formed, and the layer containing the second organic compound is formed into a film by a vapor deposition method. And thus, the number of the point defects can be reduced. Furthermore, the occurrence of a non-light emitting region generated immediately after the element has been fabricated can be also eliminated.

[0033]

A layer containing an organic compound may be laminated and formed with different methods of forming into a film, and another constitution of the invention comprises,

a method of fabricating a light emitting device having a light emitting element having an anode, a layer containing an organic compound which is in contact with the anode, and a cathode which is in contact with the layer containing an organic compound, characterized by comprising,

forming the anode,

forming an insulating material for covering the end portions of the foregoing anode,

washing a surface of the foregoing anode with a porous sponge,

forming a layer containing a first organic compound being in contact with the foregoing anode by a coating method,

performing vacuum heating immediately before a layer containing a second organic compound is formed,

forming the layer containing the second organic compound by a vapor deposition method, and

forming the cathode.

[0034]

In the constitution described above, it is characterized in that the layer

containing the foregoing first organic compound is made of a high-molecular weight material, and the layer containing the second organic compound is made of a low-molecular weight material. Moreover, it is preferable to set the temperature of the foregoing vacuum heating in the range in which the layer containing the first organic compound composed of a high-molecular weight material can be durable, and it is characterized in that the range is made in the range from 100°C to 200°C.

[0035]

In the respective constitutions described above, it is characterized in that the degree of vacuum of the foregoing vacuum heating is in the range from 1×10^{-3}Pa to 1×10^{-6}Pa, and preferably, it is in the range from 1×10^{-4}Pa to 1×10^{-5}Pa.

[0036]

In the respective constitutions described above, the step of forming the foregoing cathode is characterized in that it is carried out by a resistance heating method or a sputtering method, and it is made so as to be less damaging to a TFT.

[0037]

An EL element has a structure in which an EL layer is sandwiched between a pair of electrodes, however, usually, an EL layer has a laminated structure. Representatively, a laminated structure which is referred to as "hole transportation layer/light emitting layer/electron transportation layer" which has been proposed by Tang et al. of Kodak Eastman Company can be listed. This structure provides a very high light emitting efficiency, and at present, almost all of the light emitting devices for which the researches and developments have been progressed employ this structure.

[0038]

Moreover, except for these, structures in which hole injection layer/hole transportation layer/light emitting layer/ electron transportation layer or hole injection layer/hole transportation layer/ light emitting layer/ electron transportation layer/ electron injection layer are in order laminated on the anode may be also used. A light emitting layer may be also doped with a fluorescent pigment or the like. Moreover, these layers may be formed using a low-molecular weight material, or may be formed using a high-molecular weight material, or may be formed using an inorganic material.

[0039]

It should be noted that in the present specification, all of the layers provided between a cathode and an anode are generally referred to as a layer containing an organic compound (which is also referred to as an EL layer). Therefore, the above-described hole injection layer, hole transportation layer, light emitting layer, electron transportation layer and electron injection layer are all included in an EL layer.

[0040]

Moreover, in the present specification, a light emitting element formed with a cathode, an EL layer and an anode is referred to as an EL element, and there are two kinds of systems, a system of forming an EL layer between two kinds of electrodes in a stripe pattern provided to orthogonally cross each other (simple matrix system), and a system of forming an EL layer between a pixel electrode and a counter-electrode, which are disposed in a matrix pattern and connected to a TFT (active matrix system).

[0041]

[Embodiments Mode of the Invention]

Hereinafter, Embodiments of the present invention will be described.

[0042]

Now, an example is shown below, in which a layer containing an organic compound and the cathode are formed on an active matrix substrate in which an anode (ITO) connected to a TFT is disposed in a matrix pattern.

[0043]

First, a TFT is formed on a substrate 100 having an insulating surface. An anode (pixel electrode) 110 which is connected to drain electrodes or source electrodes 108, 107 of a TFT is formed. For an anode, metals whose work functions are large (Pt, Cr, W, Ni, Zn, Sn and In) are used, and in the present Example, an conductive film composed of ITO, which is obtained by a sputtering method, is employed. A TFT consists of a gate electrode 105, a channel formation region 102, source regions or drain regions 103, 104, drain electrodes or source electrodes 108, 107 and insulating films 106a, 106b. Herein, a p-channel type TFT, which is composed of a semiconductor film (representatively, polysilicon film) in which a channel formation region has a

crystal structure, will be exemplified below as a TFT.

[0044]

It should be noted that the top layer of an inter layer dielectric film of a TFT, that is, an insulating layer 106b being in contact with the anode 110 on its lower surface, is an inorganic insulating film (representatively, a silicon nitride film fabricated by a RF sputtering method). By providing an inorganic insulating film which is excellent in coverage, cracks of an anode to be formed on it can be eliminated. Moreover, since the amount of absorbed water on the surface can be reduced by using an inorganic insulating film, the occurrence of a shrink can be suppressed, even if the film formation of a layer containing an organic compound is performed later.

[0045]

The silicon nitride film fabricated by the RF sputtering method is a film having denseness in which silicon has been used as a target, whose etching rate using LAL500 is as slow as 0.77 nm/min to 8.6 nm/min, and hydrogen concentration in the film is measured as 1×10^{21} atoms/cm^3 by a SIMS measurement. It should be noted that LAL500 is "LAL500 SA buffered fluoric acid" made by Hashimoto Chemical and Synthetic Industries, Co., Ltd., which is an aqueous solution of NH_4HF_2 (7.13%) and NH_4F (15.4%). Moreover, as for the silicon nitride film fabricated by the RF sputtering method, since there is hardly a difference between the shifts of C-V characteristics before and after BT stress test, the blocking of alkali metal and impurities can be carried out.

[0046]

Moreover, the surface flatness can be enhanced by utilizing an organic resin film as the inter layer dielectric film 106a. Moreover, in the case where a silicon oxide film, a silicon oxide nitride film or a silicon nitride film fabricated by a PCVD method or a sputtering method is used instead of the organic resin film, the occurrence of a non-light emitting region generated immediately after the fabrication of the light emitting element and expansion of a non-light emitting region do not occur, and cracks of the anode can be also eliminated.

[0047]

Subsequently, a barrier 111 for covering the end portions of the anode 110 is formed (Fig.1(A)). The barrier 111 is formed in order to keep the insulation between the pixels which are adjacently located from each other and from the wirings by covering a contact hole of a TFT and the wiring 109. For the barrier 111, an inorganic material (silicon oxide, silicon nitride, silicon oxide nitride and the like), a photosensitive or non-photosensitive organic material (polyimide, acryl, polyamide, polyimide amide, resist or benzocyclobutene), or a laminated layer of these and the like can be used. Herein, a negative type photosensitive acryl is used. A negative type organic resin which is not to be dissolved in an etchant by light is used, a curved surface having the first curvature radius is made at the upper end portion of the barrier and a curved surface having the second curvature radius is made at the lower end portion of the barrier. It is preferable that the foregoing first curvature radius and the foregoing second curvature radius are in the range from 0.2μm to 3μm. Moreover, in the case where a positive type organic resin which is to be dissolved in an etchant by light is used, the curved surface having a curvature radius can be made only at the upper end of the barrier. The non-light emitting region generated immediately after the light emitting element has been fabricated is not to be generated by making the curved surface have a radius of curvature at the upper end portion or at the lower end portion of the barrier.

[0048]

Moreover, the barrier 111 may be covered with a protective film composed of an aluminum nitride film, an aluminum nitride oxide film, or a silicon nitride film. Since absorbed water of the surface can be reduced by covering it with a protective film composed of an inorganic insulating film, even if the formation of a layer containing an organic compound is performed later, the occurrence of a shrink can be suppressed.

[0049]

Subsequently, the surface of the anode 110 is washed (Fig.1(B)). Herein, in order to remove minute grains dotted on the surface of the anode, a surfactant (weak alkali) is made contained in a porous sponge (representatively, made of PVA (polyvinyl alcohol), made of nylon), and the surface of the anode is rubbed and washed. The

point defect or dark spot caused by minute grains can be reduced by rubbing and washing the surface of the anode, and further, the abnormality that the light emitting efficiency is extremely lowered in a drive at a low voltage (3V to 5V) can be also eliminated. It should be noted that although herein, an example in which it was washed after the formation of the barrier 111 was shown, it may be washed before the formation of the barrier 111, and it may be washed before and after the formation of the barrier 111.

[0050]

Subsequently, immediately before the layer containing an organic compound is formed, the vacuum heating for removing absorbed water in the whole substrate on which a TFT and a barrier are provided is performed (Fig.1(C)). Although baking has been previously carried out when the barrier is formed in order to degas an organic resin film, absorbed water is removed by conducting the vacuum pumping to the pressure that is equal to or less than 5×10^{-3}Torr (0.665 Pa), preferably, 10^{-4} to 10^{-6} Pa, and then, heating at 100°C to 250°C, preferably, at 150°C to 200°C, for example, for more than or equal to 30 minutes, and the natural cooling for 30 minutes immediately before the layer containing an organic compound is formed. When the experiment was performed at heating temperatures (110°C, 140°C, 170°C and 200°C), under the condition of heating at 170°C, the shrink could be the most suppressed. In the case where the vacuum heating was not sufficiently performed here, since the possibility of generating a shrink that non-light emitting region expands becomes large, it is desirable that a sufficient margin is taken for a heating temperature, a degree of vacuum and heating time. Particularly, if the uniformity is bad, since absorbed water partially remains, which causes the shrink, it is important to set an apparatus or conditions in which the whole of the substrate can be uniformly heated. It should be noted that since there may be a material that is not capable of resisting the heat treatment at 250°C, as for the vacuum heating, it is necessary to appropriately set it depending upon the inter layer dielectric film material and wiring material.

[0051]

In Fig.4, a light emitting element to which the vacuum heating has not been

performed immediately before the layer containing an organic compound is vapor deposited (conventional one) and a light emitting element to which the vacuum heating has been performed at 170°C for 30 minutes as a heating time and for 30 minutes as a natural cooling (the present invention) were compared, and the results of the amount (shrink amount) indicating how the non-light emitting region is expanded from the circumferential portion of the respective light emitting regions previously designed under the atmosphere of 95% of humidity at 65°C are shown. Four samples were prepared respectively, and the measurements were carried out. And as shown in Fig.4, all of the conventional samples shows that the non-light emitting region exists at the stage immediately after these have been fabricated, and it can be read that the amount of shrink increase along with the time passing. It should be noted that although in Fig.4, data 300 hours passed and more time passed of the conventional samples were not recorded, it was because the deterioration had progressed to such an extent where none of it could be measured. On the other hand, as shown in Fig.4, in the four samples according to the present invention, even when 700 hours and more had passed, the occurrence of a non-light emitting region and a shrink was not found.

[0052]

Subsequently, a layer 112 containing an organic compound is vapor deposited in the vapor deposit room in which the vacuum pumping has been carried out so as to be less than or equal to 5×10^{-3}Torr (0.665 Pa), preferably, 10^{-4} to 10^{-6}Pa, and on which, a cathode 113 is formed by a vapor deposition method or by a sputtering method (Fig.1(D)). As the layer 112 containing an organic compound, it may be made so as to be a layer composed of a high-molecular weight material, a low-molecular weight material, an inorganic material, or a layer in which these have been mixed, or a layer in which these have been dispersed, or a laminated layer in which these layers have been appropriately combined.

[0053]

It should be noted that since the cathode 113 gives the damage to a TFT by X-ray which is radiated when it is vapor deposited in a vapor deposition method using an electron beam, it is preferable to conduct vapor deposited using a resistance heating

method. As a material for the cathode 113, an alloy such as MgAg, MgIn, AlLi, CaF_2, CaN and the like, or a film in which an element belonging to I group or II group of the periodic table and aluminum have been formed into a film by a co-vapor deposition method may be employed in a film thickness ranging from 100 nm to 500 nm. The cathode with a thicker thickness is better to block the diffusion of water and oxygen into a layer containing an organic compound.

[0054]

Through the above-described steps, a light emitting element in which there is no shrink and no dark spot and the number of the point defects has been reduced can be formed.

[0055]

Moreover, in Fig.2 (B), a photograph in which a section at the end portion of the barrier 111 in Fig.1 was observed is shown. It should be noted that the region surrounded by chain line in Fig.2 (A) corresponds to Fig.2 (B).

[0056]

In Fig.2(A), the reference numeral 200 denotes a substrate, the reference numeral 201 denotes an under coat insulating film, the reference numeral 202 denotes a gate insulating film, the reference numeral 203 denotes an inter layer dielectric film, the reference numeral 204 denotes a silicon nitride film, the reference numeral 205 denotes a first electrode (anode), the reference numeral 206 denotes a barrier, the reference numeral 207 denotes a layer containing an organic compound, and the reference numeral 208 denotes a second electrode (cathode).

[0057]

In Fig.2(A), since the barrier 206 has a curved surface at the upper end portion 206a (a region surrounded by the dotted line in Fig.2(A)), also has a curved surface at the lower end portion 206b (the region surrounded by the dotted line in Fig.2(A)), and has an angle (taper angle) θt (θt = 35° to 70°) between the surface of the substrate and the side surface of the barrier, it is gently sloping, and the coverage of the film which is formed on it is excellent.

[0058]

Moreover, as a material for barrier, an example in the case where a positive type acryl resin was used is shown in Fig.3. In Fig.3, the shapes of the left and right sides are different from those of Fig. 2(A), however, it is a gentle sloping side surface having a curved surface only at the upper end portion.

[0059]

As a shape of the barrier, either of them will do, and they can prevent the occurrence of a non-light emitting region generated immediately after the light emitting element has been fabricated.

[0060]

Furthermore, the coverage can be enhanced by forming a layer (first layer) containing an organic compound being in contact with the anode using a coating method. An example of the steps is shown in Fig.6 (A) to Fig.6 (D). First, an anode 610 and a sloping barrier 611 are formed similarly to Fig.1(A), and the surface of the anode is washed with a sponge similarly to Fig.1(B) (Fig.6 (A)). Then, after a first layer 612a was baked by a coating method (Fig.6 (B)), and immediately after the vacuum heating (Fig.6 (C)) was further performed, a layer (second layer) 612b containing an organic compound and a cathode 613 are laminated by a vapor deposition method (Fig.6(D)). By making the film thickness of the first layer 612a 30 nm to 80 nm, preferably, 60 nm, the influence of minute grains is reduced and the number of dark spots and point defects can be reduced. At the same time, the occurrence of the non-light emitting region generated immediately after the element has been fabricated can be eliminated by enhancing the coverage.

[0061]

It should be noted that in Fig. 6 (A), the reference numeral 600 denotes a substrate, the reference numeral 601 denotes an under coat insulating film, the reference numeral 602 denotes a channel formation region, the reference numerals 603, 604 denote source regions or drain regions, the reference numeral 605 denotes a gate electrode, the reference numerals 606a, 606b denote insulating films, the reference numerals 607, 608 denote source electrodes or drain electrodes, and the reference numeral 609 denotes a wiring.

[0062]

The present invention comprising the above-described constitution will be described more in detail with Examples shown in the followings.

[0063]

[Examples]

[Example 1]

Fig.8 (A) is a top view of an active matrix type light emitting device, and Fig.8 (B) is a cross-sectional view cut along chain line A-A' or chain line B-B'.

[0064]

In Fig.8, the reference numeral 1 denotes a source signal line drive circuit, the reference numeral 2 denotes a pixel section, and the reference numeral 3 denotes a gate signal line drive circuit. Moreover, the reference numeral 4 denotes a sealing substrate, the reference numeral 5 denotes a sealing agent, and the inside surrounded by the sealing agent 5 is a space in which an inert gas dried with a desiccating agent (not shown) is filled. The reference numeral 7 denotes a connecting region connecting an upper portion electrode which is common with the respective light emitting elements and the wirings located on the substrate.

[0065]

It should be noted that a video signal and clock signal are received from a FPC (Flexible Print Circuit) 6 which is to be an external input terminal. Note that although herein, only the FPC is shown, a print wiring base (PWB) might be mounted on the FPC. Note that a light emitting device in the present specification includes not only the main body of the light emitting device, but also the state in which the FPC or PWB is mounted on it.

[0066]

Next, the cross sectional structure will be described below with reference to Fig.8 (B). A drive circuit and a pixel section have been formed on a substrate 10, however, herein, as a drive circuit, the source signal line drive circuit 1, the pixel section 2 and the terminal section are shown.

[0067]

It should be noted that as for the source signal line drive circuit 1, a CMOS circuit in which an n-channel type TFT and a p-channel type TFT are combined is formed. An n-channel type TFT has a channel formation region which is overlapped with the upper layer of a gate electrode with a gate insulating film 15 interposed therebetween, a low concentration impurity region which is overlapped with the lower layer of the gate electrode with the gate insulating film 15 interposed therebetween, a low concentration impurity region which is not overlapped with the lower layer of the gate electrode, and a high concentration impurity region which is to be a source region or a drain region.

[0068]

Moreover, a p-channel type TFT has a channel formation region which is overlapped with the upper layer of the gate electrode with the gate insulating film 15 interposed therebetween, a low concentration impurity region 62d which is overlapped with the lower layer of the gate electrode with the gate insulating film 15 interposed therebetween, a low concentration impurity region which is not overlapped with the lower layer of the gate electrode and a high concentration impurity region which is to be a source region or a drain region. Moreover, a TFT which forms a drive circuit may be formed by a known CMOS circuit, a PMOS circuit or a NMOS circuit. Moreover, although in the present Example, a driver-integrated type in which a drive circuit has been formed on the substrate is shown, it is not always necessary to be such, and it can be formed not on the substrate but in external portion.

[0069]

Moreover, the pixel section 2 is formed with a TFT for switching 70, and a plurality of pixels including a TFT for controlling the current 50 which is connected to the first electrode 28a and a first electrode (anode) 28a which is to be a lower portion electrode electrically connected to its drain region or source region (high concentration impurity region) 62b. A plurality of TFTs are formed in one pixel. The TFT for controlling the current has a channel formation region 62a which is overlapped with the upper layer of the gate electrode 66b with the gate insulating film 15 interposed therebetween, a low concentration impurity region 62d which is overlapped with the

lower layer of the gate electrode 66a with the gate insulating film 15 interposed therebetween, and a low concentration impurity region 62c which is not overlapped with the lower layer of the gate electrode 66a. It should be noted that the reference numerals 23, 24 denote source electrodes or drain electrodes, and the reference numeral 24 denotes a connecting electrode which connects the first electrode 28a to the high concentration impurity region 62b.

[0070]

In Fig.8 (B), a cross sectional view of a TFT for controlling the current 50, a TFT for switching 40 and a capacitance 41 is shown. In Fig.2, as a TFT for switching 40, an example using an n-channel type TFT having a plurality of channel formation regions 60a which are overlapped with a gate electrode 64 with the gate insulating film 15 interposed therebetween is shown. It should be noted that the reference numerals 47, 48 denote source wirings or drain wirings, the reference numeral 60b denotes a source region or a drain region, the reference numeral 60c denotes a low concentration impurity region which is not overlapped with a gate electrode 64, and the reference numeral 60b denotes a low concentration impurity region which is overlapped with the gate electrode 64. The capacitance 41 forms a holding capacitance with an electrode 46 and an electrode 63 by making the inter layer dielectric films 22, 20 as a dielectric, and further also forms a holding capacitance with an electrode 63 and a semiconductor film 42 by making the gate insulating film 15 as a dielectric.

[0071]

Moreover, as inter layer dielectric films 20, 21 and 22, a photosensitive or non-photosensitive organic material (polyimide, acryl, polyamide, polyimideamide, resist or benzocyclobutene), an inorganic material formed by a sputtering method, a CVD method or a coating method (silicon oxide, silicon nitride, silicon oxide nitride and the like), or a laminated layer of these can be used. In Fig.8, an inorganic insulating film 20 which is composed of a silicon nitride film is provided to cover the gate electrode and the gate insulating film 15, and this inorganic insulating film 20 is an inorganic insulating film which has been formed under the conditions so that hydrogen is contained in the film and which has been provided for the purpose of performing the

hydrogenation terminating the dangling bond of the semiconductor layer by performing a heating treatment. It can hydrogenate the semiconductor layer existing in lower location regardless of the existence of the gate insulating film 15 composed of a silicon oxide film. Moreover, the inter layer dielectric film 21 is selectively etched so that the upper end portion of it becomes a curved surface having a radius of curvature by a wet etching or a dry etching after the film made of a photosensitive organic material has been formed by a coating method. Moreover, in the case where an organic material is used as the inter layer dielectric film 21, it is preferable that it is covered with a silicon nitride film, a silicon oxide nitride film, an aluminum oxide nitride film or the inter layer dielectric film 22 consisted of laminated layer of these to block water, gases and impurities from diffusing from the inter layer dielectric film 21 so that a light emitting element which is formed later is not deteriorated. Moreover, the inter layer dielectric film 22 can also block the diffusion of the impurities from the substrate 10 to the light emitting element and the diffusion of the impurities from the light emitting element to the TFT, and the like. Moreover, in the case where an organic material having the moisture absorption characteristic is used as the inter layer dielectric film 21, it is necessary to bake it again since it is swollen when it is exposed to the solution such as peeling-off solution used in a patterning step later, however, it is possible to make the inter layer dielectric film 21 not swollen by covering it with the inter layer dielectric film 22.

[0072]

Moreover, the present invention is not limited to the laminating order of the inter layer dielectric films shown in Fig.8, or the order of the steps of film formation and hydrogenation, for example, after the inter layer dielectric film 21 which prevents the diffusion of the impurities is formed and hydrogenated on the inter layer dielectric film for hydrogenation, and then an organic resin material is formed into a film by a coating method, further the inter layer dielectric film 22 in which the upper end portion has been made a curved surface having a radius of curvature may be formed by wet etching or dry etching. In the case where a film composed of an organic resin is dry etched, since there is a fear that the TFT characteristics are changed by a charge being

generated, it is preferable that it is etched by a wet etching, and in the case where an inter layer dielectric film consisted of the laminated layer of an inorganic insulating film and an organic resin film is etched, only the organic resin film is wet etched, or the organic resin film may be formed and wet etched after the inorganic insulating film has been dry etched.

[0073]

In the case where a photosensitive organic resin material is used for the inter layer dielectric film 21, it tends to be a curved surface having a radius of curvature at the upper end portion as shown in Fig.8, however, in the case where a non-photosensitive organic resin material or an inorganic material is used for the inter layer dielectric film 22, it is a cross-sectional view of a contact hole as shown in Fig.1.

[0074]

Moreover, since the present Example is a case where it is made a bottom-emission type, it is desirable that a transparent material is used for the inter layer dielectric films 20 to 22.

[0075]

Moreover, at the both ends of the first electrode (anode) 28a, an insulating material (which is also referred to as bank, barrier, blocking layer, embankment or the like) 30 are formed and a layer (which is also referred to as an EL layer) containing an organic compound 31 is formed on the first electrode (anode) 28a. When the vapor deposition is performed, the organic compound has been previously gasified by resistance heating, and it flies away in the direction of the substrate by opening the shutter at the time of the vapor deposition. A layer containing an organic compound 31 which is to be a light emitting layer (containing hole transportation layer, hole injection layer, electron transportation layer, and electron injection layer) is formed by the procedure that the gasified organic compound flies away in the upper direction and is vapor-deposited on the substrate passing through the opening portion provided at a metal mask. Since the layer containing an organic compound 31 is extremely thin, it is preferable that the surface of the first electrode is flat, for example, the surface flattening may be carried out by performing the treatment for polishing it chemically

and mechanically (representatively, CMP technology) and the like before the patterning of the first electrode or after the patterning. In the case where the CMP is performed, if the thickness of an electrode 24 or an insulating material 30 is made less, or the end portion of electrode 24 is tapered, the surface flatness of the first electrode can be further enhanced. Moreover, in the case where an organic resin film is used as the inter layer dielectric film 21 in order to enhance the surface flatness of the first electrode (anode) 28a, it is preferable that the occurrence of cracks is prevented by providing an inorganic insulating film as the inter layer dielectric film 22, and the occurrence of the non-light emitting region and of the point defects generated immediately after the fabrication are suppressed. Moreover, in order to enhance the degree of cleaning on the surface of the first electrode, the occurrence of dark spots and point defects are reduced by performing the washing (brush washing and sponge washing) for the purpose of cleaning the foreign matters (dust and the like) before and after the formation of the insulating material 30.

[0076]

For the first electrode (anode) 28a, a transparent conductive film (ITO (Indium oxide-Tin oxide alloy), Indium oxide-Zinc oxide alloy (In_2O_3-ZnO), Zinc oxide (ZnO)or the like) may be employed.

[0077]

Moreover, as the insulating material 30, a photosensitive or non-photosensitive organic material (polyimide, acryl, polyamide, polyimideamide, resist or benzocyclobutene), an inorganic material (silicon oxide, silicon nitride, silicon oxide nitride or the like) formed by a CVD method, a sputtering method and a coating method, or a laminated layer in which these are laminated and the like can be employed. Moreover, when a photosensitive organic material is used as the insulating material 30, as for a photosensitive organic material, there are two kinds if it is largely classified, that is, a negative type which is not dissolved in an etchant due to the photosensitive light, or a positive type which is dissolved in the etchant due to the light. Both can be appropriately used.

[0078]

In the case where a negative type photosensitive organic material is used as the insulating material 30, as shown in Fig.2 (B), it tends to be a curved surface having a radius of curvature at the upper end portion, however, in the case where a positive type photosensitive organic material is used for that, it is a cross-sectional shape of the insulating material shown in Fig.3. Moreover, in the case where it is the insulating material 30 composed of an organic material, the insulating material 30 may be covered with an inorganic insulating film (silicon nitride film formed by a sputtering method, or the like).

[0079]

Moreover, in the case where as the insulating material 30 or the inter layer dielectric films 20 to 22, an organic material is used in order to remove gases and water in the film, it is important to perform the degassing by performing the heating treatment in the vacuum, and it is preferable that a layer containing an organic compound 31 is formed after the degassing has been performed. The occurrence of a shrink can be suppressed by performing the vacuum heating at 100°C to 250°C immediately before the film formation of a layer containing an organic compound 31 has been performed. It is preferable that the degassing is performed by performing the vacuum heating after the formation of the layer containing an organic compound 31.

[0080]

Moreover, in the case where an inorganic insulating film is used as the inter layer dielectric films 20 to 22, the film formation may be carried out by a PCVD method or a sputtering method, however, particularly, silicon is used as a target by a RF sputtering method, a silicon nitride film formed by only nitrogen gas or the mixture gas of nitrogen gas and argon gas by applying the film forming pressure at 0.1 Pa to 1.5 Pa, a high frequency power (5 to 20 W/cm^2) at 13.56 MHz, and setting the substrate temperature at room temperature to 350°C, has extremely strong in blocking effect with respect to an element such as Na, Li and the others belonging to I group or II group of the periodic table, and can effectively suppress the diffusion of these movable ion and the like. Although it is preferable that a metal film in which 0.2 to 1.5 wt% (preferably, 0.5 to 1.0 wt%) of lithium has been added to aluminum is used for the cathode in the

present Example from the viewpoints of electric charge injection characteristic and others, in the case where a material containing lithium is used for a cathode, there is a fear that the operation of a transistor is adversely affected by the diffusion of lithium, however, if it is a silicon nitride film formed by a RF sputtering method, it can prevent lithium from diffusing into the TFT.

[0081]

As for the layer containing an organic compound 31, in the case where it is made for a full color display, concretely a material layer showing the light emissions of red color, green color and blue color may be selectively and appropriately film-formed respectively by a vapor deposition method using a vapor deposition mask or by an ink jet method or the like. In the case where the layer containing an organic compound 31 showing the light emission of green color is formed, in the present Example, after α-NPD has been film-formed in a thickness of 60 [nm], Alq_3 to which DMQD has been added is film-formed as a light emitting layer of green color in a thickness of 40[nm] by using the same vapor deposition mask, Alq_3 is film-formed as an electron transportation layer in a thickness of 40 [nm], and CaF_2 is film-formed in a thickness of 1 [nm] as an electron injection layer. Moreover, in the case where the layer containing an organic compound 31 showing the light emission of blue color is formed, after α-NPD has been film-formed in a thickness of 60 [nm], BCP is film-formed in a thickness of 10 [nm] as a blocking layer using the same mask, Alq_3 is film-formed in a thickness of 40 [nm] as an electron transportation layer, and CaF_2 is film-formed in a thickness of 1 [nm] as an electron injection layer. Moreover, in the case where the layer containing an organic compound 31 showing the light emission of red color is formed, after α-NPD has been film-formed in a thickness of 60 [nm], Alq_3 to which DCM has been added is film-formed in a thickness of 40 [nm] as a light emitting layer of red color using the same mask, Alq_3 is film-formed in a thickness of 40 [nm] as an electron transportation layer, and CaF_2 is film-formed in a thickness of 1 [nm] as an electron injection layer.

[0082]

Moreover, a light emitting display device capable of performing the full color display may be made by separately providing a color filter, a color conversion layer and

the like as white color light emission. In the case where it is used as a display device or a lighting device by which only a simple display is performed, it may be made a single color light emission (representatively, white color light emission). For example, 1, 3, 4-oxadiazole derivative (PBD) having the electron transportation characteristic may be dispersed into polyvinyl carbazole (PVK) having the hole transportation characteristic. Moreover, white color light emission is obtained by dispersing 30 wt% of PBD as an electron transportation agent and a suitable amount of four kinds of pigments (TPB, coumarin 6, DCM1, and Nile red). Moreover, it is possible to obtain a white color light emission as a whole by appropriately selecting an organic compound film that emits the light of red color, an organic compound film that emits the light of green color and an organic compound film that emits the light of blue color, and then, by overlapping and mixing.

[0083]

Moreover, poly (ethylenedioxythiophene)/poly (styrene sulfonic acid) aqueous solution (PEDOT/PSS), polyaniline/camphor sulfonic acid aqueous solution (PANI/CSA), PTPDES, Et-PTPDEK, PPBA or the like which will act as a hole injection layer (anode buffer layer) may be coated and baked on the first electrode (anode) 28a. In the case where a hole injection layer composed of a high-molecular weight material formed by a coating method using a spin coat and the like was formed, the surface flatness is enhanced, and the coverage and film thickness uniformity of the film formed on it can be made excellent. Particularly, a uniform light emission can be obtained since the film thickness of the light emitting layer becomes uniform. In this case, it is preferable that after the hole injection layer has been formed by a coating method, the vacuum heating (100 to 200°C) is carried out immediately before the formation of the film by a vapor deposition method. It should be noted that an example of the steps concerning this case is shown in Fig.6. For example, after the surface of the first electrode (anode) has been washed with a sponge, poly (ethylenedioxythiophene)/poly(styrene sulfonic acid) aqueous solution (PEDOT/PSS) is temporarily baked in a thickness of 60 nm at 80°C for 10 minutes by a spin coating method on the entire surface of it and is fully baked at 200°C for one hour. And

further, the vacuum heating (170°C, heating for 30 minutes, cooling for 30 minutes) is performed immediately before vapor deposition and the formation of a light emitting layer is performed without exposing to the atmospheric air by a vapor deposition method. Particularly, in the case where convex and concave and minute grains exist on the surface of ITO film, these influences can be reduced by making the film thickness of PEDOT/PSS thicker.

[0084]

Moreover, when PEDOT/PSS is applied to the ITO film, it is not so good in wettability. And thus, it is preferable that after the coating of PEDOT/PSS solution at a first time has been carried out by a spin coating method, wettability is enhanced by once washing it with pure water, and again the second coating of the PEDOT/PSS solution is carried out by a spin coating method and then baking is performed to form a film with excellent uniformity. It should be noted that after the first coating has been carried out, the effect capable of removing minute grains or the like is obtained as the surface is properly modified by once washing it with pure water.

[0085]

Moreover, in the case where PEDOT/PSS was formed into a film by a spin coating method, since it is film-formed on the whole surface of it, it is preferable that these on the end face, the circumferential portion, the terminal section of the substrate, the connecting region of the cathode and the wirings of the lower portion are selectively removed, and it is preferable that these are removed with O_2 ashing or the like.

[0086]

Moreover, in Fig.7, the relationship between brightness and voltage of four elements (Element 1; heating at 170°C for 4 and half hours, cooling for 30 minutes, Element 2; heating at 250°C for 30 minutes, cooling for 30 minutes, Element 3; heating at 270°C for 30 minutes, cooling for 30 minutes, Element 4; heating at 170°C for 30 minutes, cooling for 30 minutes) fabricated by applying the conditions of the vacuum heating after PEDOT/PSS has been formed into a film is shown. According to the experimental results shown in Fig.7, Element 4 fabricated under the heating conditions of heating at 170°C for 30 minutes and cooling for 30 minutes shows the most excellent

brightness. Moreover, it is read from Fig.7 that Element 1 fabricated under the heating conditions of heating at 170°C for 4 and half hours and Element 3 fabricated under the heating conditions of heating at 270°C are bad in characteristic comparing to other conditions, and it is considered that PEDOT/PSS has been denatured by heat. As for Elements using PEDOT/PSS, the effects of enhancement of light emission efficiency, elongation of lifetime, and reduction of electric noises and the like are obtained. Furthermore, it can be confirmed from Fig.7 that Elements using PEDOT/PSS realize the reduction of drive voltage.

[0087]

Moreover, a second electrode (cathode) 32 which is to be an upper portion electrode is formed on the layer containing an organic compound 31 by a vapor deposition method (resistance heating method) or a sputtering method. Because of this, a light emitting element composed of the first electrode (anode) 28a, the layer containing an organic compound 31, and the second electrode (cathode) 32 is formed. In the case where the light emitting element is made white color light emission, a color filter (for the purpose of simplifying, herein, it is not shown) composed of a coloring layer and BM is provided on the substrate 10.

[0088]

The second electrode 32 functions as a wiring which is common to all of the pixels, and has been electrically connected to the FPC 6 via the wiring. It should be noted that in Fig.8, a connecting region 7 which connects a second electrode 32 to a wiring 45 is shown, and it is electrically connected to the FPC by routing the wiring 45.

[0089]

Moreover, in the terminal section, a terminal electrode consisting of laminated layer of an electrode formed by the same step with that of the gate electrode, an electrode formed by the same step with that of the source electrode or drain electrode and an electrode formed by the same step with that of the first electrode 28a, has been pasted to the FPC 6 using an adhesive such as an conductive adhesive and the like. Note that the construction of the terminal section is not particularly limited and can be appropriately formed.

[0090]

Moreover, the sealing substrate 4 is pasted together using a sealing agent 5 containing a filler in order to seal the light emitting element formed on the substrate 10. It should be noted that a spacer composed of a resin film in order to secure the interval between the sealing substrate 4 and the light emitting element may be provided. Then, an inert gas such as nitrogen or the like has been filled in the space of inside of the sealing agent 5. It should be noted that it is preferable to use an epoxy resin as the sealing agent 5. Moreover, it is desirable that the sealing agent 5 is made with a material which does not penetrate water and oxygen as much as possible. Furthermore, a substance (desiccating agent or the like) having an effect of absorbing oxygen and water may be provided within the space.

[0091]

Moreover, in the present Example, a plastic substrate composed of FRP (Fiberglass-Reinforced Plastics), PVF (poly vinyl fluoride), Mylar, polyester, acryl or the like can be employed except for a glass substrate, quarts substrate and others as a material consists of the sealing substrate 4. Moreover, after the sealing substrate 4 has been adhered using the sealing agent 5, it is also possible to be sealed with a sealing agent so as to cover the side surface (exposure surface).

[0092]

As described above, a light emitting element can be completely blocked from the external by sealing the light emitting element in the closed space, which can prevent the substances such as water and oxygen promoting the deterioration of an organic compound layer from externally invading into it. Therefore, a light emitting device having a high reliability, in which a shrink does not occurred, can be obtained.

[0093]

Moreover, the present invention is not limited to the structure of a switching TFT of the pixel section in Fig.8, for example, only an LDD region 60c which is not overlapped with the gate electrode via the gate insulating film may be provided between the channel formation region 60a and the drain region (or source region) 60b. Moreover, the shape of the gate electrode is not limited, too, and it may be made the gate electrode

in a single layer.

[0094]

In addition, although herein, a top gate type TFT has been exemplified, the present invention is possible to be applied regardless of the TFT structure, for example, it is possible to be applied to a bottom gate type (reverse stagger type) TFT and a forward stagger type TFT.

[0095]

Moreover, in Fig.8, a structure in which the first electrode 28a was formed after the connecting electrode 24 which is in contact with a source region or a drain region has been formed is shown, however, it is not particularly limited, for example, a connecting electrode which is in contact with the source region or drain region may be formed after the first electrode has been formed.

[0096]

Moreover, after an inter layer dielectric film for covering an electrode which is in contact with the source region or drain region has been further provided and a contact hole has been formed, a first electrode for connecting to an electrode on the inter layer dielectric film may be formed.

[0097]

[Example 2]

By implementing the present invention, various modules (an active matrix type liquid crystal module, an active matrix type EL module and an active matrix type EC module) can be completed. Namely, by implementing the present invention, all of the electronic equipments into which those are incorporated are completed.

[0098]

Following can be given as such electronic equipments: video cameras; digital cameras; head mounted displays (goggle type displays); car navigation systems; projectors; car stereos; personal computers; portable information terminals (mobile computers, cellular phone, electronic book, etc.) etc. Examples of these are shown in Figs. 9, and 10.

[0099]

Fig. 9 (A) is a personal computer which comprises: a main body 2001; an image input section 2002; a display section 2003; and a keyboard 2004 etc.

[0100]

Fig. 9 (B) is a video camera which comprises: a main body 2101; a display section 2102; a voice input section 2103; operation switches 2104; a battery 2105 and an image receiving section 2106 etc.

[0101]

Fig. 9 (C) is a mobile computer (mobile computer) which comprises: a main body 2201; a camera section 2202; an image receiving section 2203; operation switches 2204 and a display section 2205 etc.

[0102]

Fig. 9 (D) is a player using a recording medium in which a program is recorded (hereinafter referred to as a recording medium) which comprises: a main body 2401; a display section 2402; a speaker section 2403; a recording medium 2404; and operation switches 2405 etc. This player uses DVD (Digital Versatile Disc), CD, etc. as the recording medium, and can perform music appreciation, film appreciation, games and Internet.

[0103]

Fig. 9 (E) is a digital camera which comprises: a main body 2501; a display section 2502; a view finder 2503; operation switches 2504; and image receiving section (not shown in the figure) etc.

[0104]

Fig. 10 (A) is a cellular phone which comprises: a main body 2901; a voice output section 2902; a voice input section 2903; a display section 2904; operation switches 2905; an antenna 2906; and an image input section (a CCD and an image sensor or the like) 2907 etc.

[0105]

Fig. 10 (B) is a portable book (an electronic book) which comprises: a main body 3001; display sections 3002 and 3003; a recording medium 3004; operation switches 3005; and an antenna 3006 etc.

[0106]

Fig. 10 (C) is a display which comprises: a main body 3101; a supporting base 3102; a display section 3103 etc.

[0107]

In addition, the display shown in Fig. 10 (C) has the small and medium sized or the large-sized, for example a size of 5 to 20 inches of screen. Further, to manufacture the display section with such sizes, it is preferable to mass-produce by executing a multiple pattern using a substrate which has 1 m on a side.

[0108]

As described above, the applicable range of the present invention is extremely large, and it can be applied to a manufacturing method of electronic equipments in various field. Further, the electronic equipments of this Example can be achieved by utilizing any constitutions of combination of Embodiment and Example 1.

[0109]

[Effect of the Invention]

According to the present invention, a light emitting device without dark spots and without point defects can be completed. Furthermore, a light emitting device having a high reliability without causing a shrink can be realized even if the long period of time passes.

[Brief Description of the Drawings]

[Fig.1] Views showing a process according to Embodiment.

[Fig.2] A diagram and a TEM photograph showing Embodiment.

[Fig. 3] A TEM photograph.

[Fig. 4] A graph showing the relationship between the amount of a shrink and time for the purpose of comparing the present invention with the conventional one.

[Fig. 5] A graph showing the relationship between current and voltage in a light emitting element for the purpose of comparing the present invention with the conventional one.

[Fig.6] Views showing an example of steps of Embodiment.

[Fig.7] A graph showing the relationship between brightness and voltage when the

vacuum heating conditions are changed.

[Fig.8] A top view and a cross-sectional view showing Example 1.

[Fig.9] Drawings showing examples of electronic devices (Example 2).

[Fig.10] Drawings showing examples of electronic devices (Example 2).

[Fig.11] Views showing how a shrink expands along with the time passing.

[Fig.12] Views showing how a dark spot expands along with the time passing.

[Fig.13] A cross-sectional TEM photograph of a portion that poorly emits the light.

[Fig.14] A result showing the EDX measurement of the portion that poorly emits the light (POINT 1).

[Fig.15] A result showing the EDX measurement of the portion that poorly emits the light (POINT 2).

[Fig.16] A result showing the EDX measurement of the portion that poorly emits the light (POINT 3).

[Document Name] Abstract

[Summary]

[Problem] It is an object to reduce or eliminate generation of various defective modes (shrink, dark spot etc.) in a light emitting element having an organic compound.

[Solving Means] According to the present invention, non-light emitting region is suppressed immediately after a light emitting element is fabricated, by making a barrier 111 have a curved surface having a radius of curvature at the upper end portion or lower end portion. And generation of a shrink is suppressed by washing the surface of an anode 110 with a porous sponge for removing minute grains dotted on the surface of the anode and by conducting a vacuum heating for removing water absorbed entirely in the substrate in which a TFT and a barrier are provided immediately before a layer containing an organic compound 112 is formed.

[Selected drawing] Fig.1